Advanced accelerator Group

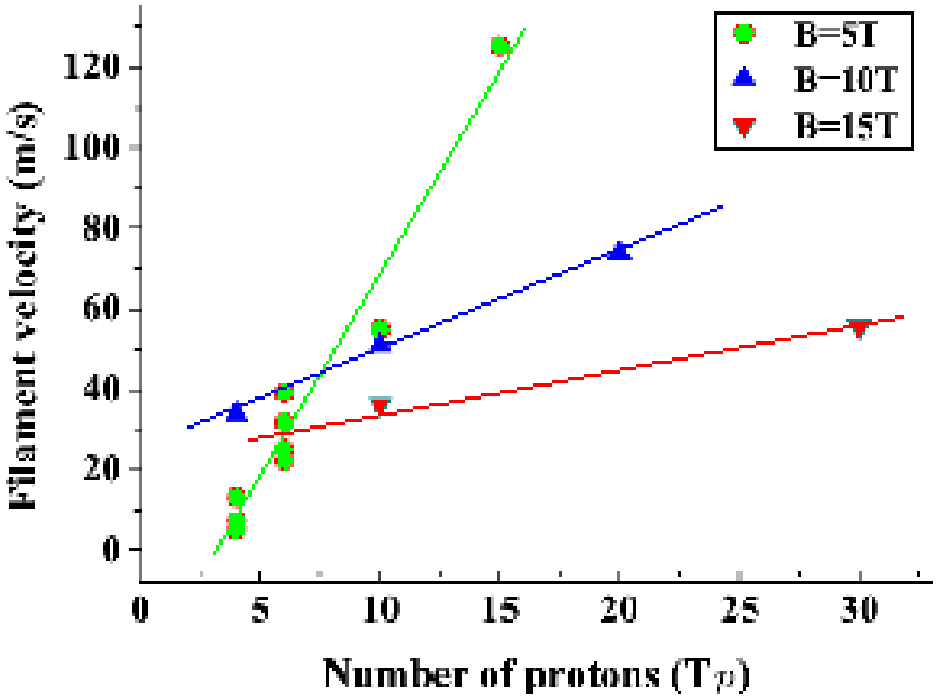
- Staff
  - Bob Palmer
  - Scott Berg
  - Rick Fernow
  - Juan Gallardo
  - Harold Kirk
  - (Diktys Stratakis Post Doc recently left)
- Visitors & Collaborators
  - Al garren Particles Beams lasers
  - Steve kahn Muons Inc
  - Kirk McDonald Princeton
  - X Ding UCLA
- Graduate Students
  - Jon Lederman UCLA
  - Robert Ott SUNY-SB
  - Yan Zhan SUNY-SB

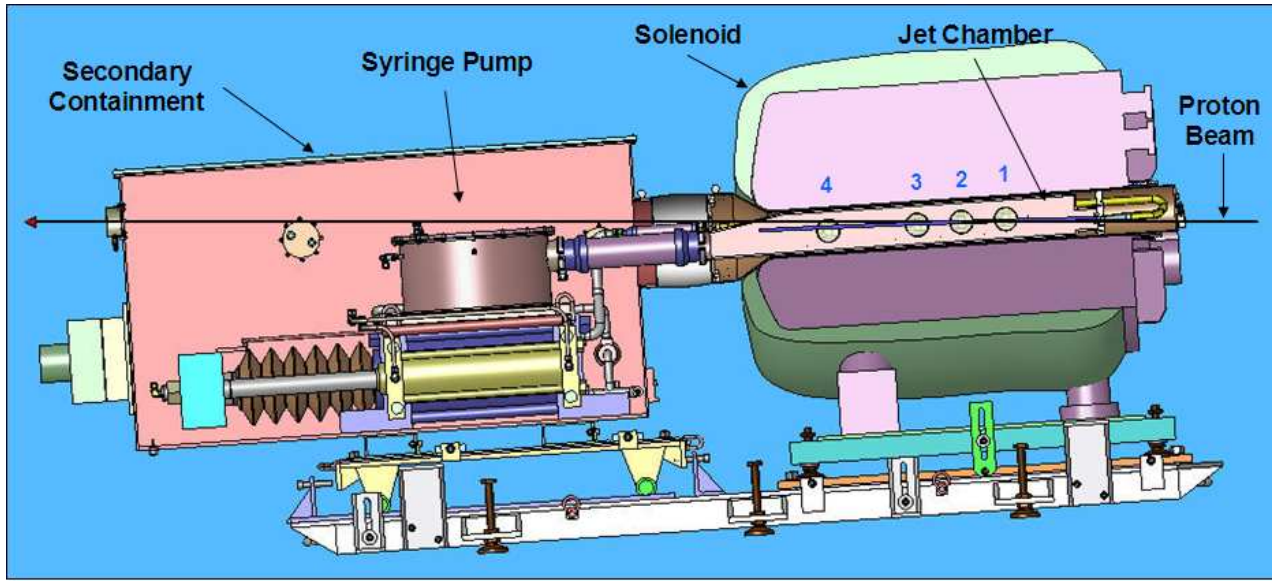
BNL Activities

- Mercury target experiment (MERIT) at CERN
- Cooling system design and simulation
  - New 6D merge
  - Progress towards end-end cooling simulation
- Theory of rf breakdown in magnetic fields
  - Tests of two solutions
- Design of 50 T solenoids, and experiment towards 40 T
- Simulations and support for emittance exchange in MICE
- Fixed Field alternating Gradient FFAG acceleration
  - electron model (EMMA) in the UK
- Role in Muon Accelerator Program (MAP)

Targetry & MERIT Experiment

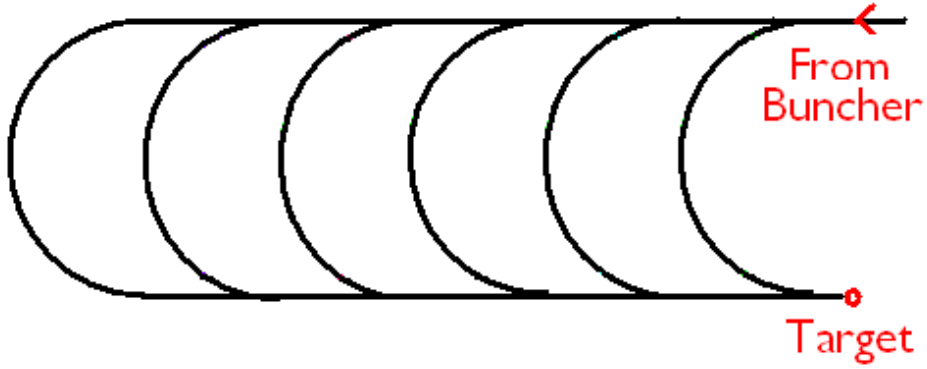
- MERIT demonstrated liquid mercury target for multi-megawatt beams
- Splash velocities moderate and reduced by magnetic field
- Remaining need to improve jet quality

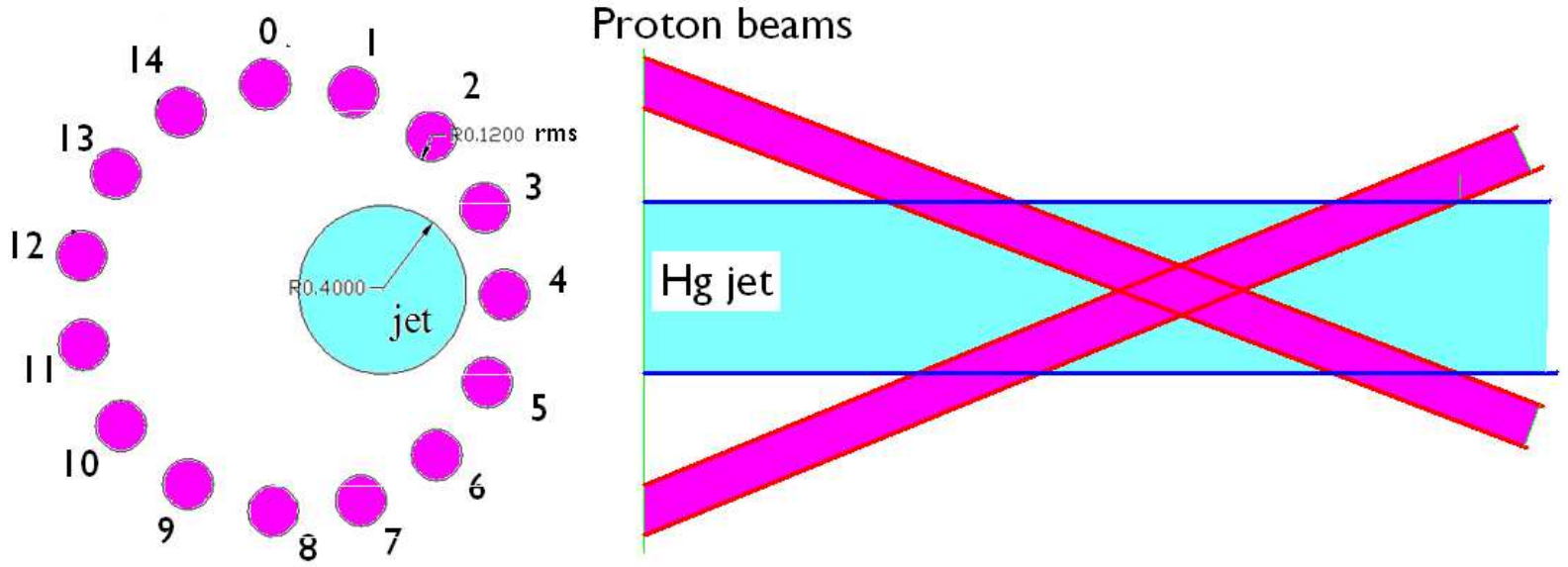




Target Simulations

Kicker sends successive bunches into transports with differing lengths. All are combined on target at same time

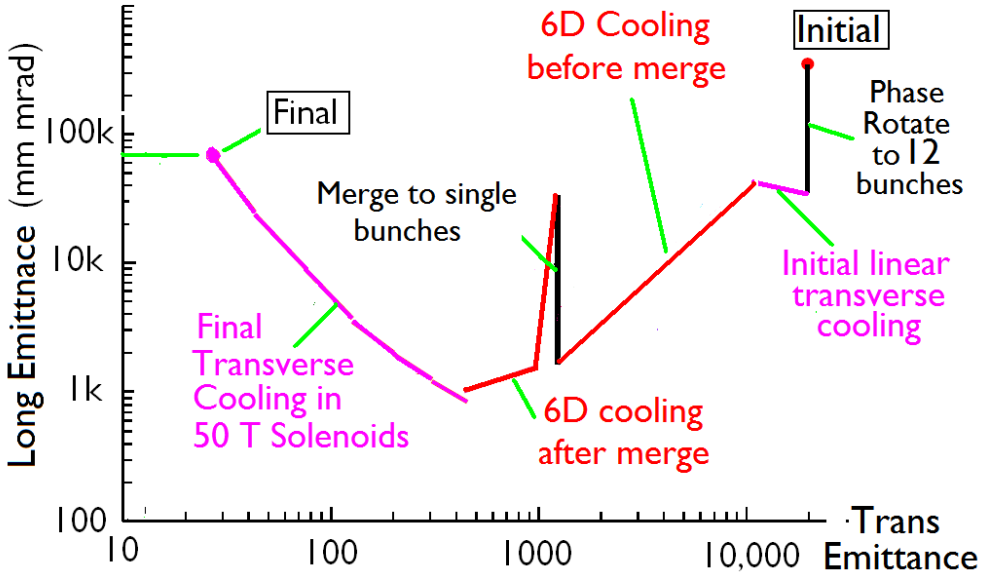




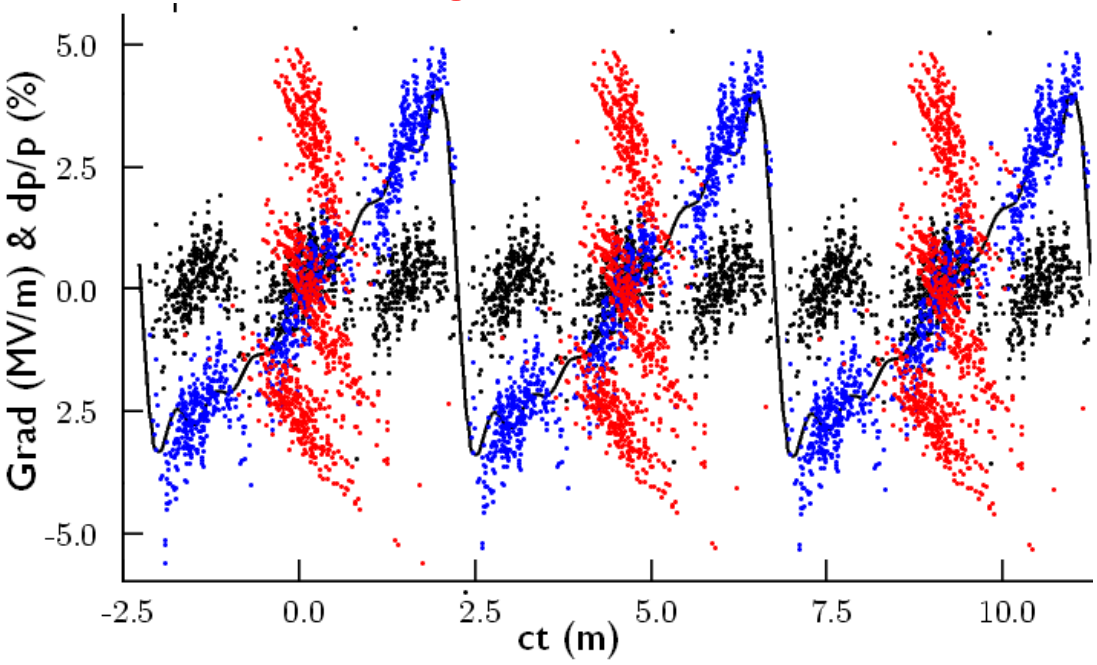
- Proton bunch space charge for collider is a problem at 8 GeV
- Reduced by 'trombone' and merge
- Simulations show little loss (<5%) by multiple beams on target

Simulations of new 6D merge

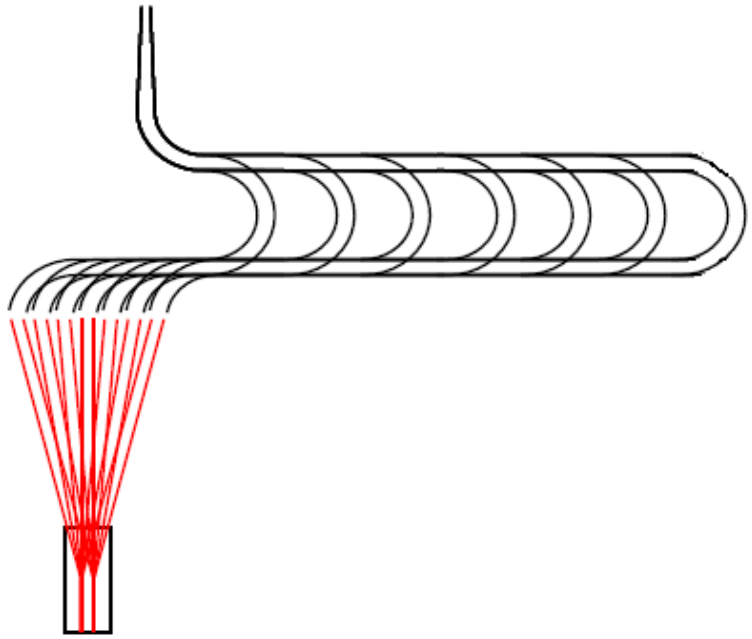
Old 2D
merge concept



New 6D merge

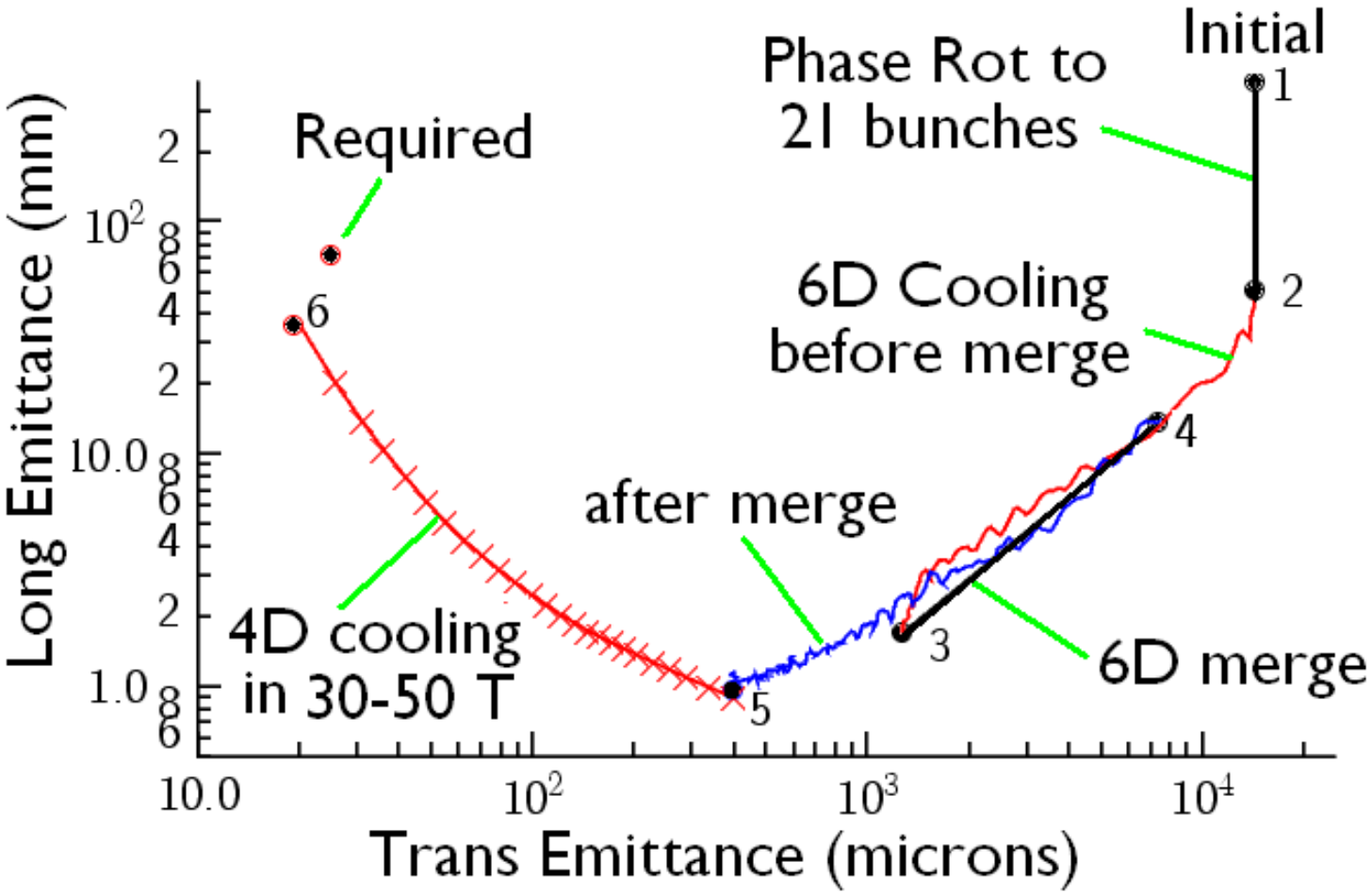


Long merge 21→ 7



Transverse merge 7 → 1

Tapered cooling with 6D merge



- 'Continuous' simulation from target to #5
- Separate simulations of 4D cooling in 30-50 T solenoids
- Emit exchange in 6D simulated with matrix

New production and transmission estimate

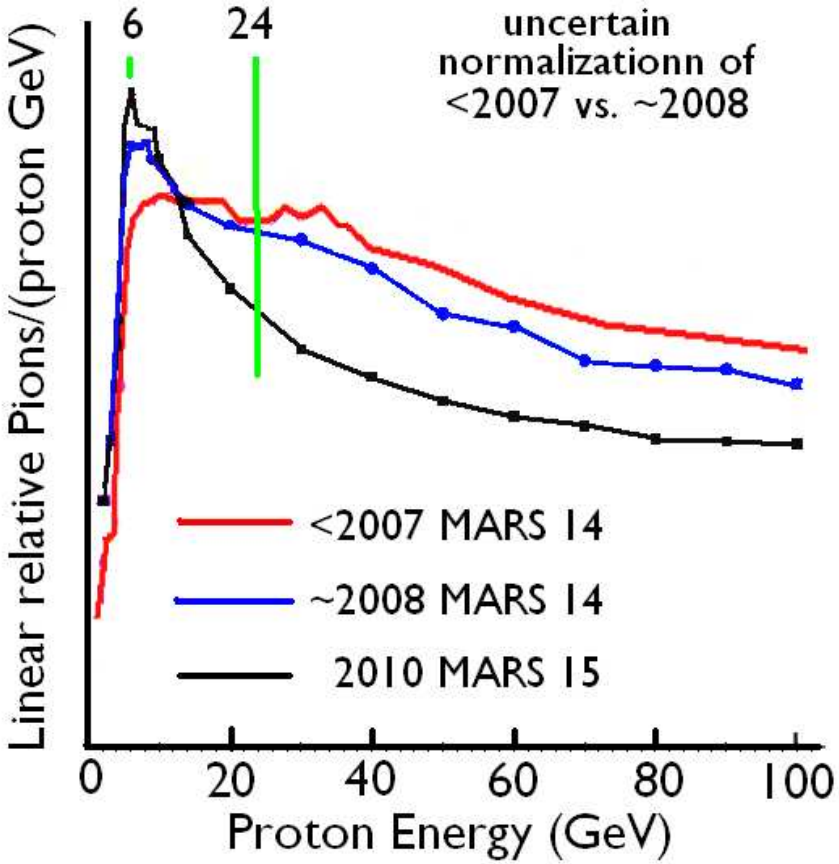
	old	transmission	cumulative	mu/p
After rotation				0.334
Momenta = 226 ± 100 MeV/c		0.654	1.0	0.219
Best 21 bunches	(0.7)	0.7	0.7	0.153
Charge separation	(1.0)	0.85	0.59	0.129
6D Cooling before merge	(0.5)	0.468	0.28	0.061
Merge	(0.7)	0.88	0.25	0.055
6D Cooling after merge	(0.5)	0.48	0.12	0.026
50 T Cooling	(0.7)	0.7	0.08	0.018
Acceleration	(0.7)	0.7	0.06	0.013

- Transmission less than previous (7→6.0 %) from charge separation
- But initial production is better, from 8 GeV and MARS 15 (Next slide)

For 2 10^{12} muons 1.54 10^{14} protons/bunch
Power at 12 Hz: $12 \times 1.5410^{14} \times 810^{9} \times 1.610^{-19} \; = \; 2.36$ MW

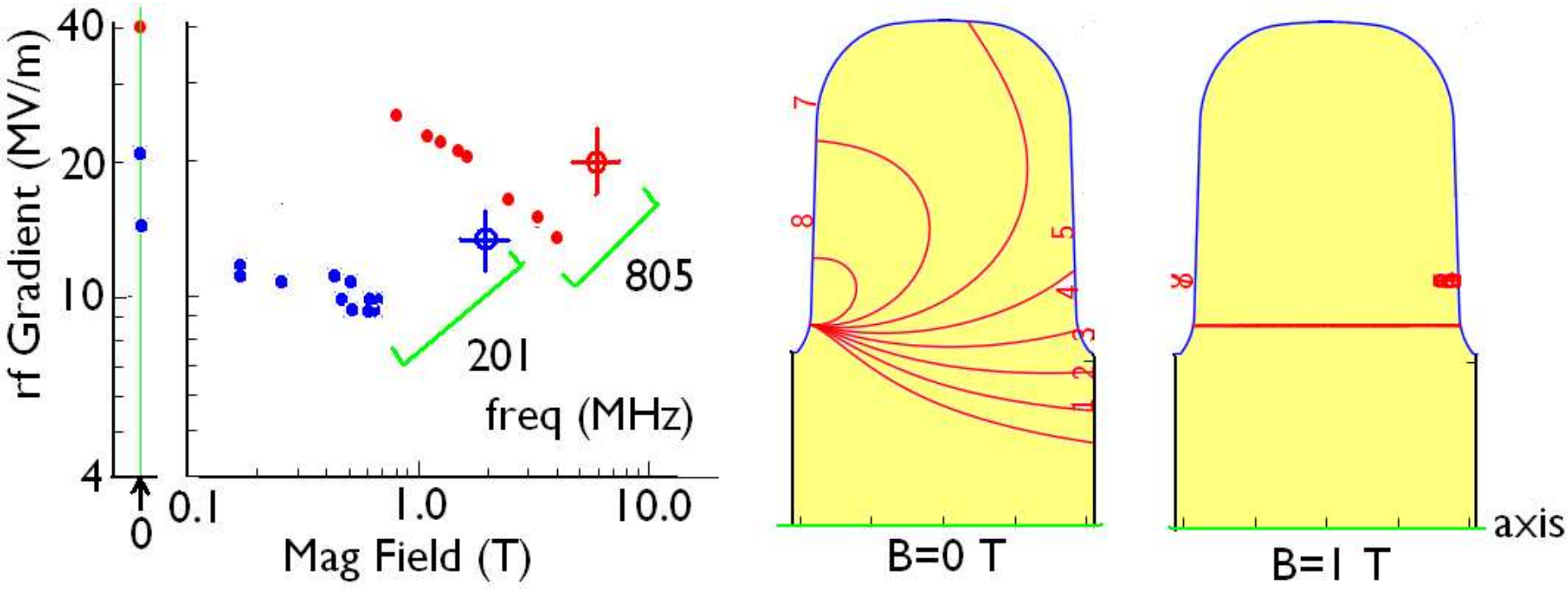
- Power is less than previous (4→2.36 MW)
- Production uncertainty greater than simulation's

Pion Production uncertainty



- Earlier simulations assumed 24 GeV for reduced space charge
- Predicted production now shows big advantage at 6-8 GeV
- This prediction has appeared relatively recently
- Production experiments (HARP & MIPP) not sufficient
- Experiment with our geometry needed

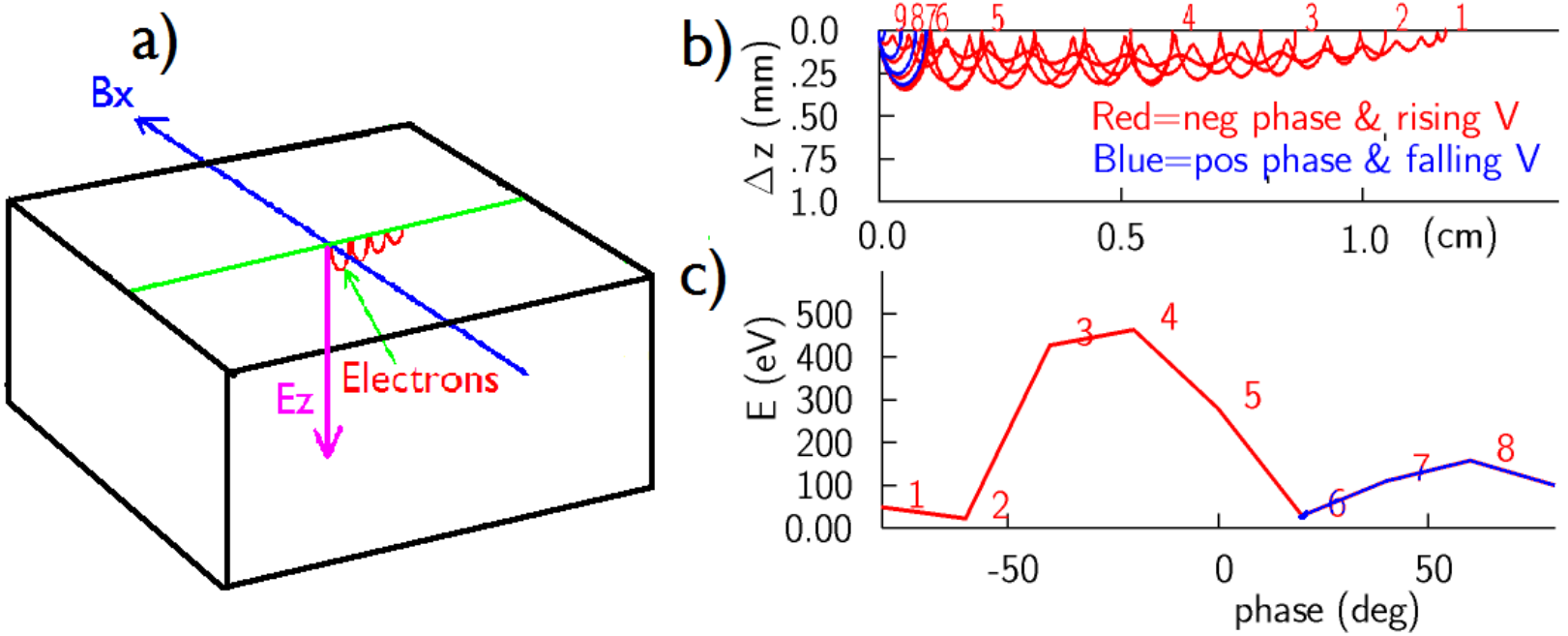
rf breakdown in Magnets



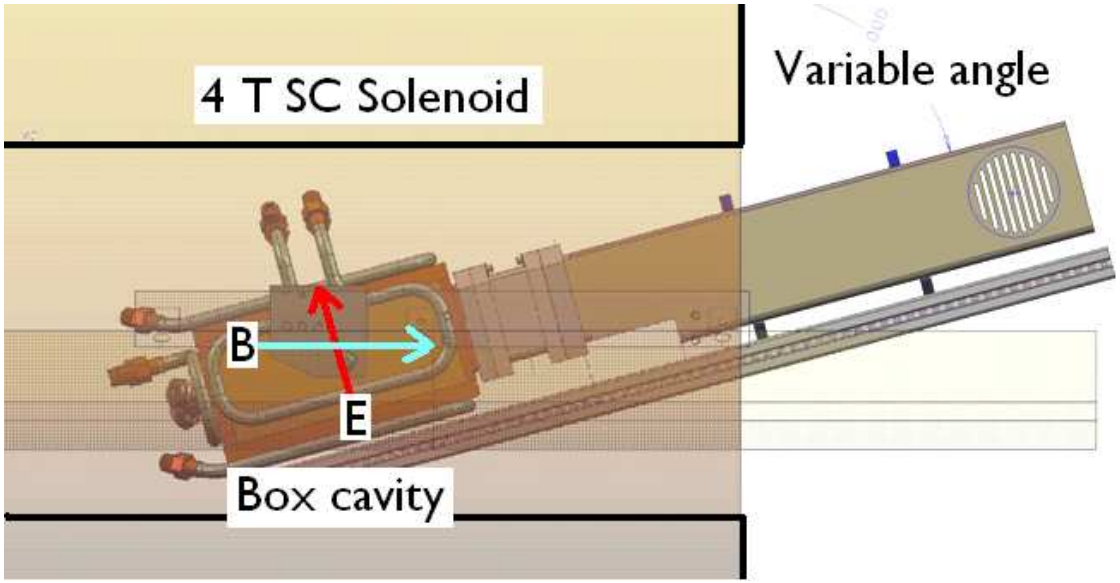
- Theory:
  - Electrons from field emission accelerated to $\approx$ 1 MeV
  - Focused by field, fatigue damage from from cyclical heating to T>100 deg.
- Solutions ?
  - Use high pressure gas Question in beam difficulty for low beta
  - Magnetically insulate
  - Use beryllium

Magnetic Insulation

Concept and simulation in box cavity

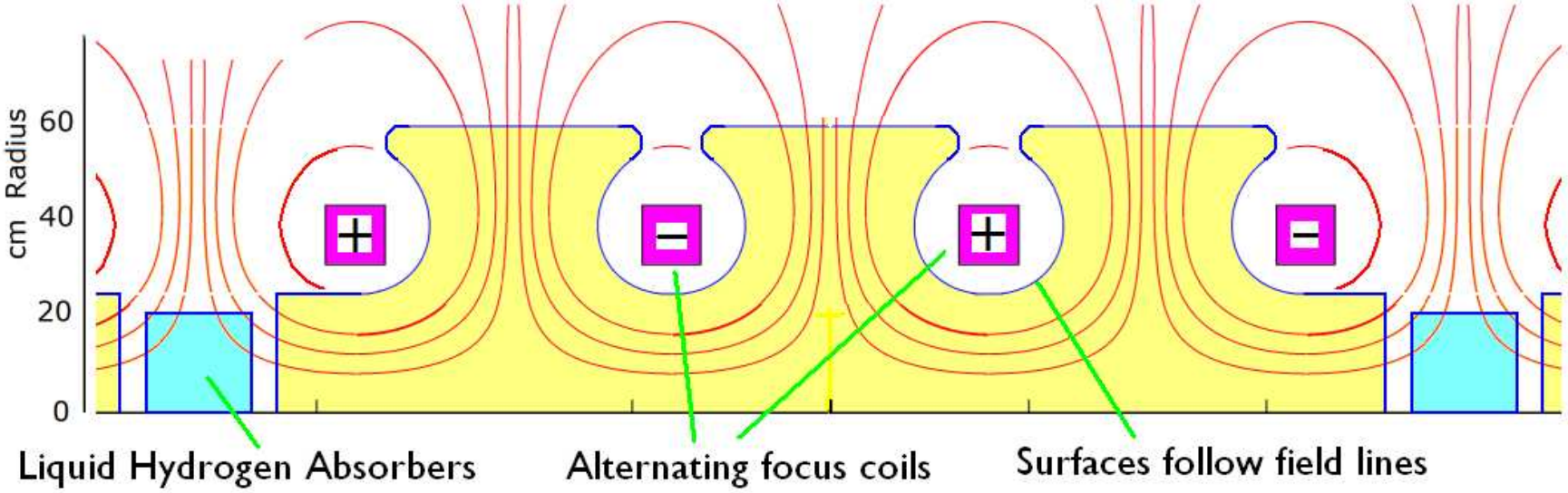


Exp now running at FNAL with variable angle

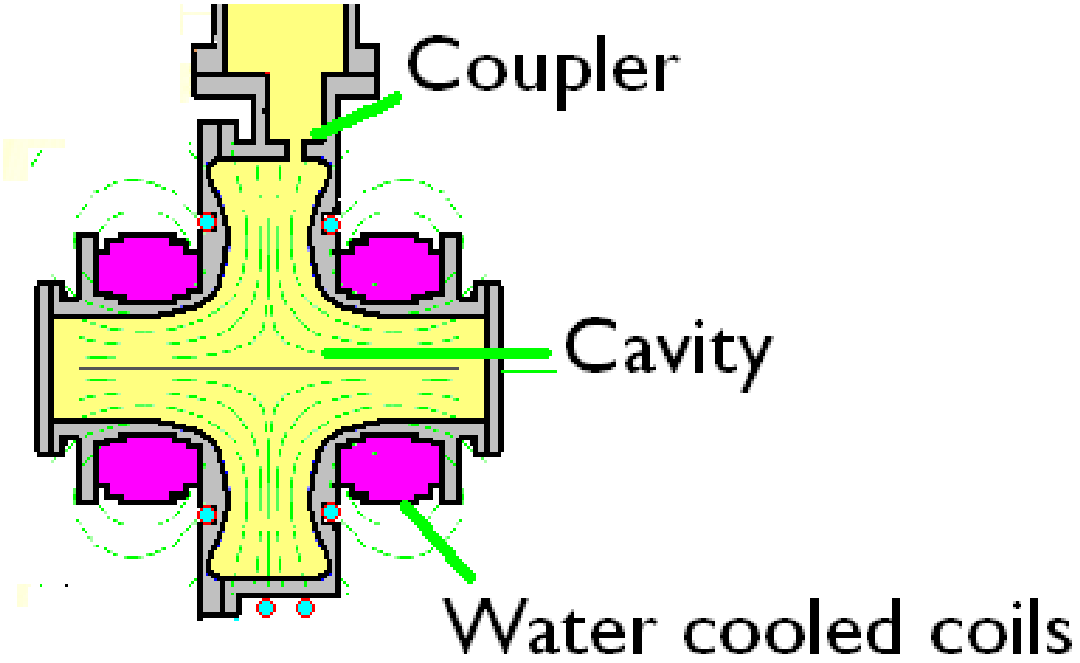


Proposed PBL SBIR Phase II Experiment

Concept for cooling with magnetic insulation

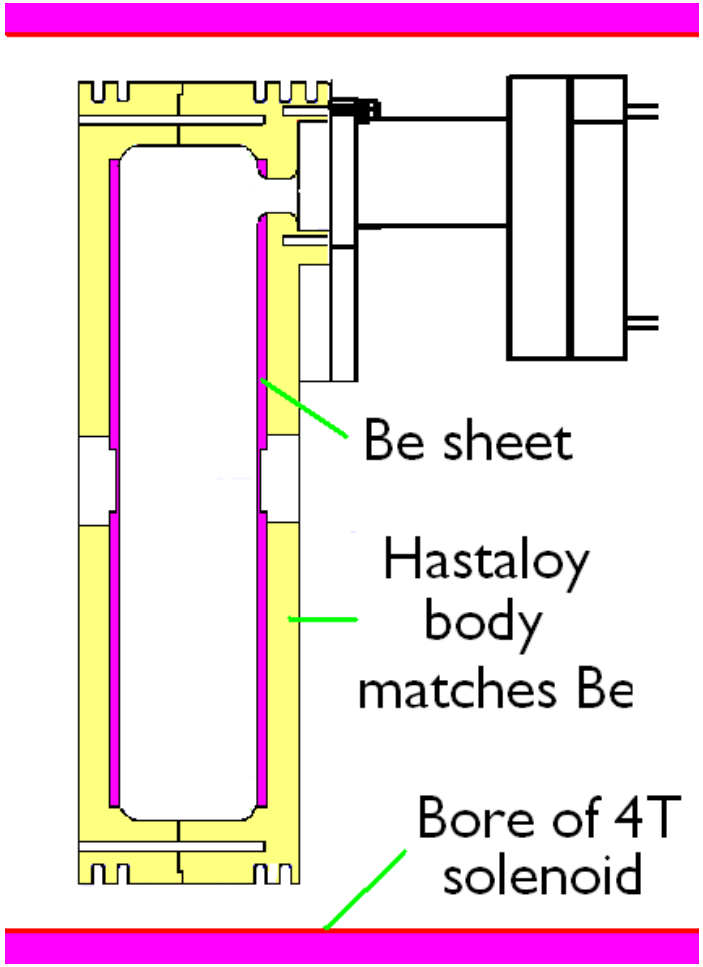


Proposed SBIR Experiment

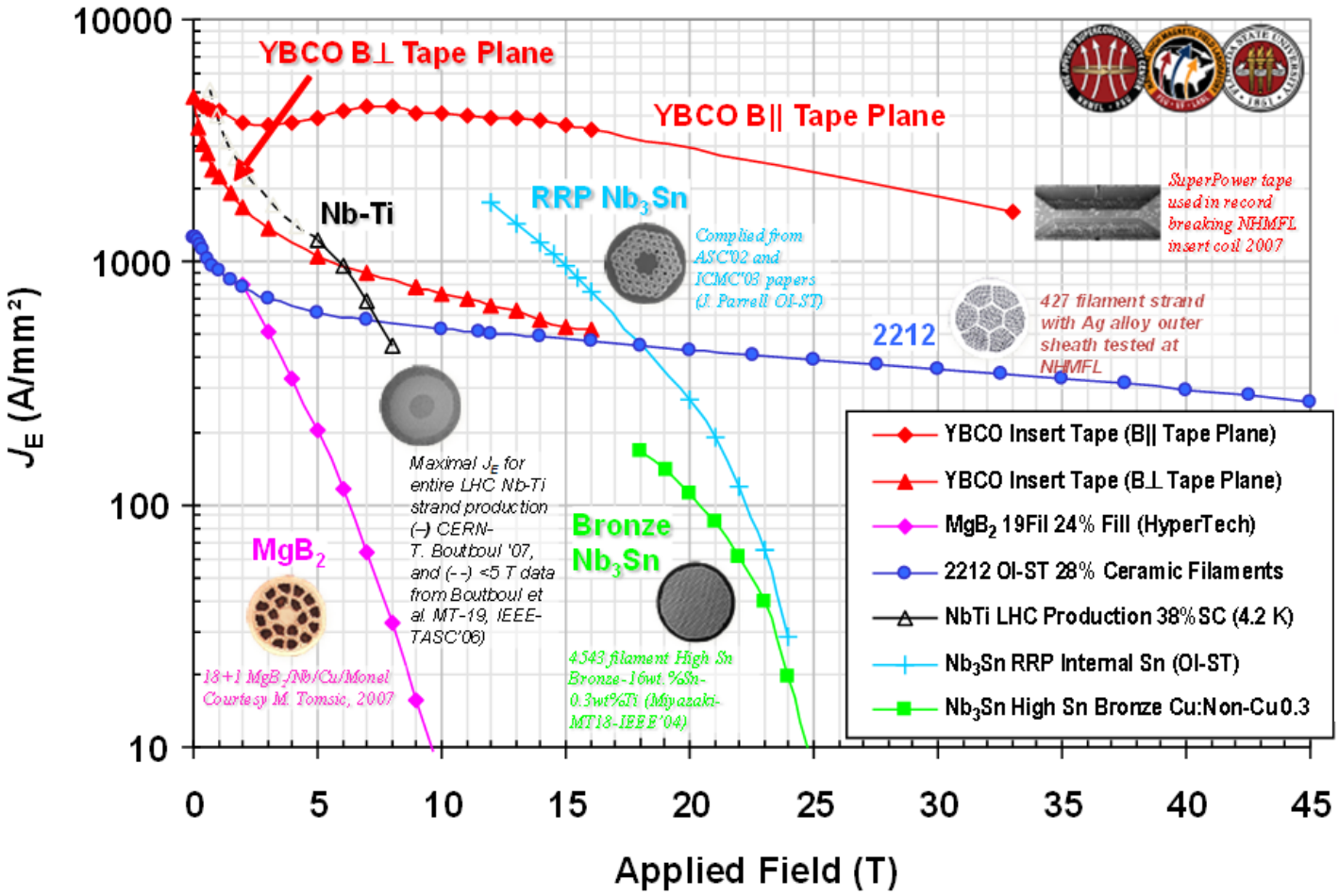


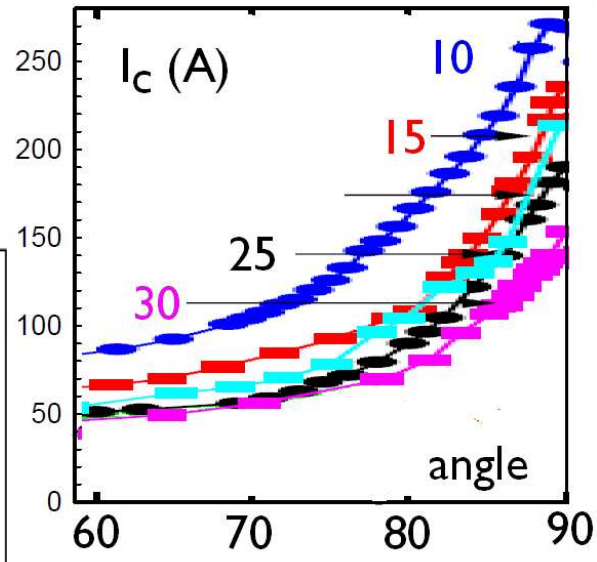
Use of Beryllium (with LBNL)

- Low density and strength predict much less damage
- Simulations at BNL
- Ongoing design at LBNL



R&D towards 50 T solenoids

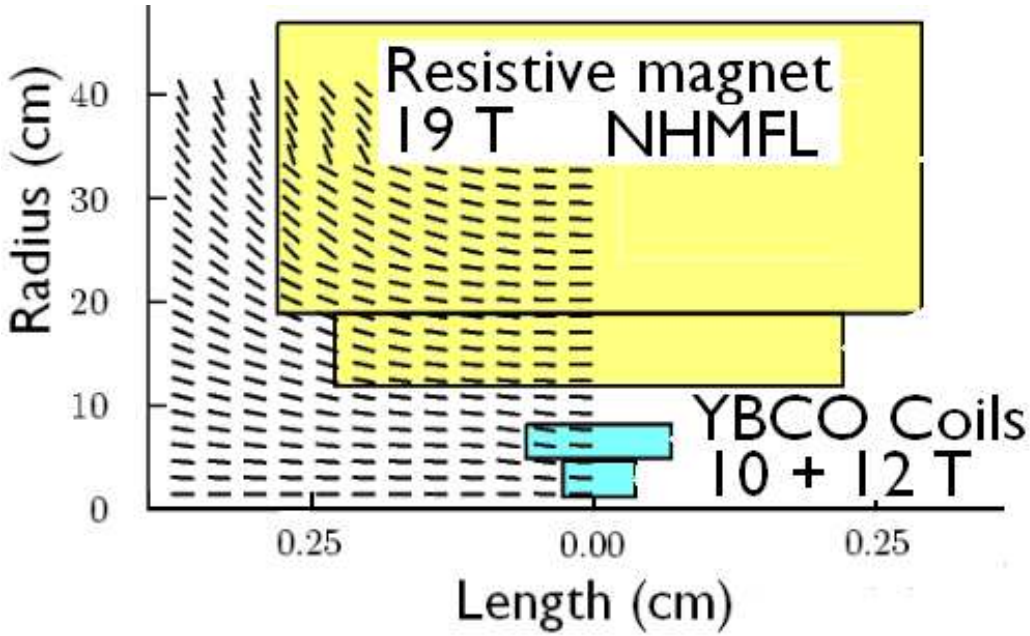




- YBCO has highest Engineering Current Density j_E
- Angle dependent
- But even in bad direction as good as BSCO
- Can a real magnet use it

PBL Phase II SBIRs with Magnet Div towards 40 T solenoid

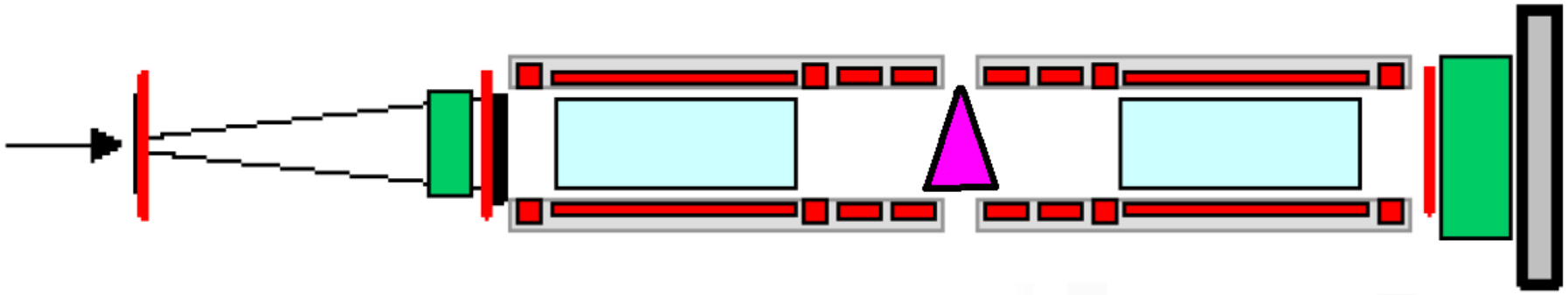
- 10 T YBCO outer solenoid
  first SBIR
- 12 T YBCO inner solenoid
  second SBIR
- Nested for ≈ 20 T
- In NHMFL 19T: ≈ 40 T



13 of 28 Coils for outer 10 T
each tested at 70 deg
4 deg test when all finished

Involvement with International Programs

- Work on International Design Study (IDS) of a Neutrino Factory
  - Leading role in acceleration
- 6D cooling in MICE using plastic or LiH wedge
  - BNL Simulations



  - Dispersion by weighting
  - Cooling in all dimensions
  - But no re-acceleration
- Leading role in electron model of non-scaling FFAG: EMMA
  Next slide

Electron model of non-scaling FFAG EMMA

Berg had leading role in design
and will go to UK for initial tests

Proposed Muon Accelerator Program (MAP)

- MAP Level 1 leader of design and simulation (Fernow)
- Member of Management Council (Palmer)

MAP Manpower projections

	Y1 FY10?	Y2 FY11?	Y3 FY12?	Y4 FY13?
MAP Total FTEs	31	40	51	58
MAP BNL FTEs	5	7	8	8

- BNL DOE funded effort is now 4 Staff + 1 Post-Doc + 1/2 Secretary
- 2/3 of one Staff funded by BNL overhead

- Increasing BNL MAP effort from 5 to 8 will not be easy
- Need to be able to offer tenure track and joint University appointments

Conclusion

- MERIT has shown Hg target multi-megawatt viability
- Significant progress towards end-end cooling simulation
- Question on pion production
- Theory of rf breakdown in fields
- BNL involvement in experiments on two solutions
  - Magnetic insulation
  - Use of Beryllium
- Study towards 50 T solenoids
  - 20 T YBCO HTS in 19 T NHMFL resistive $\longrightarrow$ 40 T test
- Prospect of expansion under MAP